

## **SECTION 703 LIGHTING & SIGNAL MATERIALS**

**703.01 GENERAL.** Furnish all electrical equipment meeting the requirements of the National Electrical Manufacturers Association (NEMA) or the Radio Manufacturers Association (RMA), whichever is applicable. Meet the Contract requirements, the National Electrical Code (referred to as the Code); the standards of the American Society for Testing Materials (ASTM); the American National Standards Institute (ANSI); and all state and local laws or ordinances that may apply.

References to the above codes or standards are the current editions of the code, order, or standard at the time the contract is let and governs throughout the life of the contract.

Furnish galvanized parts and meeting ASTM A 153, B 454 (Class 50), or other applicable ASTM galvanizing specifications. Anchor bolts may be galvanized, or cadmium plated with type NS coating meeting ASTM A 165. Galvanized bolts and nuts must thread together without damaging the coating.

### **703.02 CONDUIT**

**703.02.1 Plastic Conduit.** Furnish rigid polyvinyl chloride meeting UL 651, schedule 40 and 80, 150 °F (66 °C) wire rated, direct bury type. Install conduit meeting the applicable requirements of Section 616.

**703.02.2 Steel Conduit.** Furnish galvanized rigid steel conduit and fittings of mild steel meeting UL 6 and ANSI C 80.1 requirements.

Cut a 12-inch (305 mm) sample, witnessed by the Project Manager, from the end of each conduit size for testing. Tests will be by ASTM A 239.

Install conduit meeting the applicable requirements of Section 616.

### **703.03 PULL BOXES.**

**703.03.1 Concrete Pull Boxes.** Furnish concrete pull boxes, extensions, and covers made of reinforced concrete. Use class "DD" concrete meeting Section 551 requirements. Use reinforcing steel meeting Section 555 requirements.

Meet the pull box size and details specified in the Contract.

Inscribe reinforced concrete covers for signal systems, or combined signal and low-voltage lighting systems with the words "TRAFFIC SIGNALS". Furnish reinforced concrete covers for lighting systems inscribed with the words "STREET LIGHTING" ("HIGH VOLTAGE" where specified). Provide two 3/8-inch (9.5 mm) brass or stainless steel hold-down bolts, washers and nuts with the cover. Recess the nuts below the surface of the cover. Furnish a steel cover designed to withstand AASHTO H-20 loads for pull boxes subject to traffic loads.

Assure pull boxes are watertight. Seal the covers with a 1/4-inch (6 mm) bead of asphaltic mastic in the cover recess. Make conduit enter from the bottom of the box.

Furnish metal frames and covers for boxes or vaults formed in the concrete. Inscribe covers with the wording specified in the Contract. Assure gasket surfaces form a true plane. Install a 1/8-inch (3 mm) one piece neoprene gasket on the frame or cover for the seal.

**703.03.2 Metal Pull Boxes.** Furnish metal pull boxes made from cast iron with a checkered steel cover, both hot dip galvanized. Attach the cover to the box with brass or stainless steel screws. Provide the cover with a gasket that, with the cover in place, forms a NEMA Type 4 watertight fit. Boss, drill, tap and treat conduit entrances to the box for corrosion protection. Meet the pull box size and details shown in the Contract.

**703.03.3 VACANT.**

**703.04 STANDARDS AND POSTS.**

**703.04.1 General.** Furnish standards fabricated under Section 556 and designed meeting the AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals".

Use a minimum luminaire dead load of 75 pounds (34 kg), and a minimum luminaire projected area of 3.3 square feet (0.31 m<sup>2</sup>) for design purposes. Use a design wind velocity for all standards of 90 miles per hour (145 km/hr).

All standards must be steel. Once the standards, posts, or pedestals are erected and the installation complete, grout any gap between the base and foundation using grout meeting Subsection 713.05 requirements. Form a 3/4-inch (19 mm) drain hole in the grout at the lowest point.

Install standards or posts as specified in the Contract.

**703.04.2 Type 2 and 3 Signal Standards.** Furnish a single steel section shaft formed into a round, continuous taper with a single, automatic electrically welded seam, or an approved equal.

Show the type of steel used for the shafts on the shop drawings.

Provide four high-strength steel anchor bolts with each shaft. Furnish each anchor bolt with two nuts and two washers over and under the shaft base to adjust rake and plumb.

Field drill other holes for wire entry, mounting pedestrian and vehicle signals, or pedestrian push buttons. Treat the holes or threads with a cold galvanizing compound following the manufacturer's directions.

All accessories welded to the shaft must be factory-welded before galvanizing.

Furnish raintight metal covers for the top of Type 2A and 3A signal standards.

**703.04.3 Type 10 Luminaire Standards.** Shafts must be a single section formed into a round, continuous taper with a single, automatic electrically-welded seam, or approved equal. Steel shafts must be a minimum No.11 Manufacturer's Standard Gauge.

Show the type of steel on the manufacturer's shop drawings.

Provide a rain-tight cover for the top of each shaft.

Shafts **not mounted** on transformer bases must have a handhole with removable cover and an internal grounding lug, as shown on the plans. Locate the handhole in the same quadrant as the mast arm.

Shafts **mounted** on transformer bases do not require a handhole or grounding lug.

The shaft base (anchor or breakaway) to be used is specified in the Contract.

The shaft base plate must be a one-piece plate circumferentially welded to the shaft for anchor and breakaway base types.

For anchor bases, the base plate must attach directly to the anchor bolts. Furnish each anchor bolt with two nuts and two washers for plumbing and raking the shaft.

For breakaway bases, the plate must be attached to a breakaway device that attaches to the anchor bolts.

Use breakaway bolt couplings unless they will not function with the approved luminaire standard. The bolt coupling must meet AASHTO publication, "Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals" requirements.

Use frangible transformer bases where bolt couplings cannot be used. Transformer bases must have an access door, grounding lug, and factory-made shims for plumbing. Provide each anchor bolt with one nut and one washer.

Provide four high strength steel anchor bolts with each shaft. Furnish "L" shaped anchor bolts with a minimum 6-inches (155 mm) of the bolt threaded at the top. Size the anchor bolt following the shaft manufacturers recommendations.

Anchor bolts used with breakaway bolt couplings must project out of the foundation the length recommended by the coupling manufacturer. Furnish the breakaway bolt coupling, washer, nut and bolt covering that enclose the area between the baseplate and foundation.

Anchor bolts used with transformer bases must project at least 3-inches (75 mm) from the foundation.

Provide a mounting base where the mast arm connects to the shaft. Provide an opening in the base for running wire from the shaft to the mast arm.

Field drill other holes for wire entry, mounting pedestrian and vehicle signals, or pedestrian push buttons. Treat the holes or threads with a cold galvanizing compound following the manufacturers recommendations.

All accessories welded to the shaft must be factory-welded before galvanizing.

**703.04.4 Mast Arms - Signal and Luminaire.** Mast arms must be single tapered members.

The mast arm end must have a 2-inch (50 mm) slip-fitter tenon at least 6-inches (155 mm) long.

All accessories welded to the mast arm must be factory-welded before galvanizing.

Mast arm lengths and mounting heights are shown on the plans.

**703.04.5 Type 1-80, 1-100, 1-120, 1-140, and 1-160 Signal Standards.** Furnish standards as specified in the Contract.

Furnish a cast aluminum base with an internal ground lug and handhole with removable cover. Plumb bases with factory-made shims. Provide a nut and washer with each anchor bolt for the base.

Anchor bases may be used when a single conduit enters the shaft base. The anchor base must be a one-piece steel plate circumferentially welded to the shaft before galvanizing. Furnish two nuts and two washers with each anchor bolt for plumbing and raking the standard.

Provide four high strength steel anchor bolts with each shaft. Furnish "L" shaped anchor bolts with a minimum 6-inches (155 mm) of the bolt threaded at the top.

Leave anchor bolts projecting at least 3-inches (75 mm) from the foundation.

Follow the manufacturer's recommendations for anchor bolt size and bolt circle.

Field drill holes for wire entry, mounting pedestrian and vehicle signals, or pedestrian push buttons. Treat the holes or threads with a cold galvanizing compound following the manufacturer's recommendations.

All accessories welded to the shaft must be factory-welded to the shaft before galvanizing.

**703.04.6 Welding Steel.** Meet the American Welding Society Specifications for Welded Highway and Railway Bridges, AWS D-1.1-75 and AWS D1.1 or current revisions, and as amended by AASHTO and the Montana Supplemental Specifications for Welding (blue sheets found in the contract).

Furnish weld procedures with the shop drawings showing complete welded joint details including material, process, procedure, filler metal, welding technique, workmanship, dimensional tolerances for each type joint used in fabrication, pre-heat, interpass, and heat treatment temperature schedules.

**703.04.7 VACANT.**

**703.04.8 Finish.** Furnish standards galvanized inside and out. A primer finish is not acceptable. Use stainless steel or zinc, cadmium, or galvanized coated fasteners. Provide galvanized nuts, washers, and shims for anchor bolts.

**703.04.9 Wire Protection.** Use insulated bushings or grommets to prevent wire abrasion at all wire openings and inlets.

**703.04.10 Inspection.** All standards will be inspected at the project before they are erected and may be inspected where fabricated.

**703.05 CONCRETE FOUNDATIONS.** Use Class "D" concrete for all foundations for standards.

Concrete quantity increases for foundations to accommodate the standard furnished by the manufacturer are at Contractor expense.

Construct foundations to accommodate the steel conduit and anchor bolts as specified.

Pancake grounds cannot be used.

Reinforce foundations with No.4 (#10M) hoops at 1'-0" (305 mm) centers and with eight No.6 (#20M) bars equally spaced around the hoops. Form the top 6-inches (155 mm) of the foundation, beveling the exposed concrete edge 2-inches (50 mm). Electrically bond all conduit in each foundation to an anchor bolt using a AWG No.6 copper grounding strap. Connect a bare copper AWG No.6 solid wire between the grounding lug on the standard and the grounding strap.

**703.06 CONDUCTORS AND CABLE.**

**703.06.1 Conductors.** Furnish conductors of solid or stranded copper of the gauge shown in the Contract.

Insulation for conductors must be Type THW, XHHW, USE, RHH, RHW, THWN, or THHN.

All insulation must be designed for 600 volts and meet the code requirements.

Supply connectors and fuses shown in the Contract and required to complete the work. Furnish watertight connectors, with midget ferrule type fuses.

**703.06.2 Signal Cable.** Furnish cable meeting the International Municipal Signal Association (IMSA) Specification No.19-1 or 20-1.

Individual conductors must be stranded copper.

Use spade-type connectors.

**703.06.3 Detector Loop Shielded Cable.** Use cable as a lead-in between the loop pull box and the loop detector as specified.

Furnish with an aluminum-polyester shield with two AWG No.14 stranded, tinned, polyethylene-insulated copper conductors, a stranded and tinned copper AWG No.18 or 16 drain wire, all encased in a black polyethylene jacket meeting IMSA Specification No.50-2.

Ground the drain wire at the controller cabinet and dead end where the cable connects to the loop wires.

Make cable to loop wire connections within the pull boxes or signal standards with soldered, waterproof splices.

No other splices are allowed.

**703.06.4 Emergency Preemption Detector Cable.** Run the cable from the detector head to the discriminator.

Follow the preemption manufacturers recommendations for detector cable connections at the discriminator and detector head.

No splices are allowed in the cable.

**703.07 SERVICE AND CONTROL ASSEMBLY.** Equip and locate service and control assemblies as shown on the plans. Meet the Code and local utility company requirements.

Furnish cabinets meeting NEMA Type 3, 3R, or 12, made of aluminum or code-grade steel having a hinged, lockable door.

Furnish the Project Manager three keys to the lock.

Include a terminal strip having the number of attaching points for the required conductors with the service and control assembly. Assure the terminal strip has the capacity equal to an AWG No. 6 conductor. Run a bare AWG No.6 solid copper ground wire from the cabinet to a 5/8-inch (16 mm) by 8 foot (2.4 m) copperweld ground rod and clamp, as shown in the plans.

Provide all steel conduit, ground wire, insulated clevis, service wire, all mounting hardware and fittings to complete the work.

Construct photoelectric controls and their associated wires meeting Subsection 703.14 requirements.

**703.08 SIGNAL CONTROLLERS.**

**703.08.1 General.** Furnish traffic signal equipment meeting the National Electrical Manufacturer's Association (NEMA) Standards Publication No. TS 1-1976 through TS 1-1989 for traffic control systems.

The equipment must also comply with the Radio Manufacturers Association, National Electric Code, ASTM, ANSI, MUTCD and state plus local requirements.

Warrant the entire cabinet and electronics to be free from defects in workmanship and material for six months from the date of installation. Replace any defective parts at Contractor expense.

Assure a signal controller and cabinet manufacturer's representative is present at the signal turn-on to provide technical assistance in setting up, checking out, and demonstrating that the signal meets functional requirements.

**703.08.2 Traffic Actuated Controller.** Furnish a controller that is a micro-processor based solid state traffic responsive machine that provides 4 pedestrian phases and 4 vehicle phases for the Type 4-A-SS, and 4 pedestrian phases and 8 vehicle phases for the Type 8-A-SS. The 4-A-SS must have two programmable phase overlaps and the 8-A-SS must have four programmable phase overlaps.

The basic elements for the controller must be on modules that are plug connected to the main frame assembly and interchangeable between Traconex controllers. The controller must have an RS232 port capable of upload, download, modem connection, using a DB25 system connector.

The controller must have an internal time clock to enable outputs such as coordination, flash, dial, split, and offset choices. Timing must be accomplished by digital methods and utilize the power line frequency as a base. All automatic time corrections or synchronization except from power outages must be made at 12:00 midnight.

The controller must have an internal coordinator capable of being a master or slave with the appropriate inputs/outputs for 6 dials, 3 splits, and 3 offsets. Coordination must not interfere with non-coordinated signal operation when any other NEMA controller with the same number of phases is substituted.

Assure each phase has identical control capabilities, features, and options. The options and features for each phase must be able to be exercised independently of the options and features exercised on other phases. All controller unit timing intervals and phase options must be programmable from the front panel via a keyboard pad without the use of tools or special auxiliary units. The controller must be menu driven with an LCD display having at least 4 lines, 40 characters long.

The front panel must display the following information:

1. Presence of Vehicle Calls and Actuations on each phase;
2. Presence of Pedestrian Calls on each phase;
3. Termination of phase because of Gap-Out;
4. Termination of phase because of maximum Time-Out or Force-Off;
5. Maximum 2 in effect;
6. Phase Timing;
7. Phase Next;

8. Interval Timing;
9. Time remaining in interval;
10. Hold in effect;
11. Controller at rest;
12. Preemption.

The front panel must permit programming the following functions and display their status:

1. Phases that are to be enabled for the specific intersection configuration;
2. Concurrent pedestrian phases that are to be enabled for the specific intersection configuration;
3. Flashing or steady walk outputs per phase;
4. Phase that is to rest in walk if there are no conflicting calls;
5. Phases that guarantee timing of the pedestrian clearance intervals when under manual control;
6. Phases assigned to non-actuated #1 and #2 inputs;
7. Start up phase and phase indication;
8. Start up flashing time;
9. Phase Overlaps.

Overlaps must be programmable from a NEMA overlap card or from the front panel. The programming must consist of assigning the overlapped phases to the respective overlap.

It must be able to display previously programmed data stored in the controller from the front panel. The parameter called for and its current programmed value must be displayed without interruption of the controllers cyclic operation. It must be possible to change any programmed values while the controller is operating.

All display indicators must have a minimum design life of 20,000 hours at the rated voltage.

- A. Cabinet.** The controller and auxiliary equipment making up the rest of the controller unit with the exception of the preemption detectors and their lead-in cable must be housed in a weatherproof cabinet. Furnish a NEMA Type 3R rated and UL listed cabinet.

Fabricate the cabinets from sheet aluminum at least 0.125-inches (3.2 mm) thick, adequately reinforced, and weatherproof. The cabinet exterior must have a factory-applied prime coat and grey powder coated finish. The cabinet interior must have a white finish.

Provide the main cabinet door with a handle and a tumbler lock keyed for a Corbin #2 key. Equip the auxiliary door with a lock for a standard police key. Furnish two keys for each lock. The door must lock automatically when the door is closed and latched, with the key removed.

Furnish the cabinet with a door stop assembly to hold the door open at approximately 90° and 150°.

Cabinet sizes are as follows:

**"H" Cabinet:** Pole mounted cabinet.

Minimum dimensions: 42-inches (1066 mm) high x 26-inches (660 mm) wide x 17-inches (430 mm) deep.

**"M" Cabinet:** Pedestal mounted cabinet.

Minimum dimensions: 51-inches (1295 mm) high x 30-inches (765 mm) wide x 17-inches (432 mm) deep.

**"P" Cabinet:** Pedestal mounted cabinet.

Minimum dimensions: 56-inches (1422 mm) high x 44-inches (1118 mm) wide x 26-inches (660 mm) deep.

Furnish two anchor bolts with "M" cabinets. Furnish 4 anchor bolts with "P" cabinets. Furnish two washers and one nut with each bolt. Furnish bolts meeting the manufacturer's recommendations. Furnish hardware to pole mount the "H" cabinets.

Equip cabinets with an electric fan rated at 100 cfm (2.8 m<sup>3</sup>/min.) minimum. Mount the fan in the top of the cabinet in a manner that prevents rain from entering. The fan must be thermostatically controlled and manually adjustable to turn on between 70 °F (20 °C) and 150 °F (65 °C). Fuse the cabinet fan circuit 125% of the capacity of the fan motor.

Furnish the cabinet with louvered filtered vents in the front door. Mount a removable air filter with a metal retainer spring inside the cabinet door behind the louvered vents.

Mount an incandescent lamp on the inside top of the cabinet, near the door. The lamp must provide illumination whenever the cabinet door is open. Florescent lamps are not acceptable.

Equip cabinets with a 150-watt strip heater with a variable adjustable thermostat on a separate circuit breaker and switch.

Supply 4 copies of the cabinet wiring diagram, 1 copy of the operating manual for each device, and 1 copy of the manual for controller P. C. software. Place the wiring diagram in a heavy duty clear plastic pouch, attached to the inside of the main cabinet door. This pouch must be of a material and design that it provides storage and access to the wiring diagram.

Submit a schematic wiring diagram of the controller and auxiliary equipment before purchasing. This diagram must detail all circuits and parts. Identify the parts shown by name or number. Furnish parts that are readily available and non-proprietary.

**B. Cabinet Wiring.** The cabinet wiring must provide the following services:

Cabinets must have interface panels capable of terminating a 12 conductor wire 120 volt interconnect and 4 conductor telemetry. A master cabinet must have a relay driven 120 volt panel. A slave cabinet must have a solid state 120 volt panel. This interface panel must provide the following functions:

1. Offset 1
2. Offset 2
3. Offset 3
4. Dial 2
5. Dial 3



6. Dial 4
7. Flash
8. Split 2
9. Coordination/Free
10. Split 3
11. AC common from Master
12. Spare

Wire cabinets with a plug-in mounted (solid state) flasher, and jack mounted relays to permit any combination of flashing red or yellow lights. Operation shall cut in flasher and isolate controller from signal light circuits. The NEMA flash circuit must not be controlled by the controller.

Furnish a readily accessible mounting panel in each controller cabinet with provisions for terminating all field circuits.

Wire "H" cabinets for 6 load switches, (4 vehicle and 2 pedestrian). Wire "M" cabinets for 9 load switches, (4 vehicle, 4 pedestrian and 1 overlap). Wire "P" cabinets for 14 load switches, (8 vehicle, 4 pedestrian and 2 overlap).

Terminate the spare output circuits of pedestrian load switches on field terminals for future use.

The cabinet must include a police panel with the following switches:

<b><u>Switch</u></b>	<b><u>Function</u></b>
Auto-Flash	The <u>Flash</u> position shall place the intersection in Flash and turn the conflict monitor and Opticom off and stop time the controller. Assure the controller begins its mode of operation in the startup routine upon return from the Flash position to the Auto position.
Main Switch	The <u>On</u> position shall provide normal operation. The <u>Off</u> position shall remove power from the cabinet, with the exception of the convenience outlet.

Include an auxiliary test panel with the following switches for the cabinet:

<b><u>Switch</u></b>	<b><u>Function</u></b>
Auto-Flash	The <u>Flash</u> position shall place the intersection in Flash and allow the controller and auxiliary equipment to operate.
Stop-Time	The <u>On</u> position shall apply stop timing to (On-Off-Auto)the controller. The <u>Auto</u> position shall allow the conflict monitor or other external source to apply stop timing to the controller. The <u>Off</u> position shall remove any external stop timing applied to the controller.

Each phase shall have vehicle and pedestrian push buttons to place calls on the phase. Six for "H" cabinets, 8 for "M" cabinets, and 12 for "P" cabinets.

Include a 15 amp fused convenience ground fault outlet with the auxiliary test panel. Wire the outlet so it remains functional even with the main switch or main circuit breaker in the off position.

The cabinet must contain an input power panel with the following:

1. Main Circuit Breaker: 40 Amp for 4-A-SS, 50 Amp for 8-A-SS
2. 20 Amp Auxiliary Equipment Circuit Breaker
3. 50 Amp RIS
4. Transient Voltage Protector
5. Neutral Bus Bar
6. Base-Mounted MOV rated at 70 joules or greater
7. Ground Bus Bar
8. 50 Amp Mercury Contactor
9. Gas Tube Lightning Arrester

Wire a transient voltage protector into the cabinet.

The power input for the controller, conflict monitor and other control equipment, exclusive of the flasher circuitry, must come from the transient voltage protection device that protects against abnormalities of less than one-half cycle duration. The protector must be a solid state high energy circuit containing no spark gap, gas tube or bar component.

The devices current rating must equal or exceed 15 amps.

The protection must be a transient suppression of 200 volts peak, a transient response of less than five nanoseconds, a power dissipation of 10,000 watts, and an overvoltage response of five seconds. The protector must function with a 10 x 1000 microsecond wave form clamping no greater than 200 volt peak.

Wire cabinets to provide for a conflict monitor. Provide cabinet interlock circuitry which automatically places the intersection signals on flashing operation if the conflict monitor is disconnected while the controller is operating the signals and the cabinet door is closed.

Wire cabinets for rack mount vehicle detectors. "H" and "M" cabinets must have a 6 position rack. "P" cabinets must have a 10 position rack. Assign rack slots with slot 1 being for phase 1 detector, slot 2 for phase 2 detector with other slots following this example. Reserve slots 5 and 6 for Opticom in "H" and "M" cabinets. Reserve slots 9 and 10 for Opticom in "P" cabinets. Equip all racks with an external wall mount fused +24 volt DC regulated power supply rated at 2.4 amps.

Install a panel mounted on the lower left side of the cabinet having terminals to terminate loop lead-in cables and up to 4 pedestrian push button lead-in cables for the type 4-A-SS and 8-A-SS controllers.

Pin assignments for the 4th connector are as follows:

PIN	FUNCTION	I/O	ADDRESS BIT
1	Emergency Preempt 4 Out	O	\$62-3
2	Offset 3 Out	O	\$61-2
3	Offset 4 In (Add Bit 3)	I	\$61-3
4	ON LINE	I	\$61-5
5	Spare	O	\$62-7
6	Dial 4 In	I	\$60-3
7	Dial 6 In	I	\$60-5
8	Special Function 2 Out	O	\$61-6
9	Split 3 In	I	\$60-7
10	Offset 2 In (Add Bit 1)	I	\$61-1
11	Flash Out	O	\$62-6
12	Offset 1 In (Add Bit 0)	I	\$61-0
13	System Detector 8	I	\$63-7
14	Dial 5 In	I	\$60-4
15	Special Function 3 Out	O	\$61-7
16	Split 2 In	I	\$60-6
17	System Detector 1 (Seq #1)	I	\$63-0
18	System Detector 4 (Seq #4)	I	\$63-3
19	System Enable	I	\$61-6
20	Dimming On	I	\$61-7
21	Split 2 Out	O	\$60-6
22	Emergency Preempt 2 Out	O	\$62-1
23	Railroad Preempt Out	O	\$62-4
24	Spare	O	\$62-5
25	Dial 2 In (Special Function 2)	I	\$60-1
26	Coordination On (Special Function 1)	I	\$60-0

PIN	FUNCTION	I/O	ADDRESS BIT
27	Coordination Out	O	\$60-0
28	Special Function 1 Out	O	\$61-5
29	Dial 4 Out	O	\$60-3
30	System Detector 5 In	I	\$63-4
31	System Detector 3 (Seq #3)	I	\$63-2
32	Emergency Preempt 1 Out	O	\$62-0
33	Offset 1 Out	O	\$61-0
34	Emergency Preempt 3 Out	O	\$62-2
35	Dial 3 In (Special Function 3)	I	\$60-2
36	Offset 3 In (Add Bit 2)	I	\$61-2
37	Flash Status In	I	\$62-7
38	Offset 5 In (Add Bit 4)	I	\$61-4
39	System Detector 6 In	I	\$63-5
40	System Detector 7 In	I	\$63-6
41	Offset 4 Out	O	\$61-3
42	Offset 2 Out	O	\$61-1
43	Dial 2 Out	O	\$60-1
44	Dial 3 Out	O	\$60-2
45	Offset 5 Out	O	\$61-4
46	Split 3 Out	O	\$60-7
47	System Detector 2 (Seq #2)	I	\$63-1
48	Logic Ground		
49	Emergency Preempt 1 In	I	\$62-0
50	Emergency Preempt 2 In	I	\$62-1
51	Dial 5 Out	O	\$60-4
52	Dial 6 Out	O	\$60-5
53	Logic Ground		

PIN	FUNCTION	I/O	ADDRESS BIT
54	Logic Ground		
55	Emergency Preempt 3 In	I	\$62-2
56	Emergency Preempt 4 In	I	\$62-3
57	Railroad Preempt In	I	\$62-4
58	Conflict Status In	I	\$62-5
59	Reserved		
60	Flash Command In	I	\$62-6
61	Reserved		
62	Reserved		
63	Chassis Ground		

Wire cabinets for Opticom emergency preemption equipment. Provide interface terminals for two Model 562 discriminators wired as follows:

**4-A-SS**

Discriminator #1	Channel A = Ø1
Discriminator #1	Channel B = Ø3
Discriminator #2	Channel A = Ø2
Discriminator #2	Channel B = Ø4

**8-A-SS**

Discriminator #1	Channel A = Ø1 & Ø6
Discriminator #1	Channel B = Ø3 & Ø8
Discriminator #2	Channel A = Ø2 & Ø5
Discriminator #2	Channel B = Ø4 & Ø7

Provide the necessary logic and wiring to allow the following operation:

1. Immediate advance of the controller to the clearance intervals of the phase timing.
2. All clearance intervals to be timed as set on the controller.
3. After proper clearances the controller shall go directly to the preempted phase bypassing any intervening phases in the normal sequences.
4. During preemption all pedestrian indications to hold in DON'T WALK.
5. Following preemption, place a minimum vehicle recall on all phases.

The Opticom interface panel must provide terminations for up to 4 Model 521 Opticom detectors for the type 4-A-SS and 8-A-SS controllers. One detector must be assigned to correspond to each of the channels available on the discriminator.

Mark all wiring for easy identification. Use permanent labels.

**703.08.3 Conflict Monitor.** Furnish a self-contained solid state conflict monitor able to detect the presence of conflicting signal indications and the absence of proper voltage at the field connection terminals of the red signals. It must be able to monitor for the presence of proper operating voltages in the controller and also within itself.

The conflict monitor must monitor switch fail conditions, inadequate yellow timing and have serial communications for a printer or computer.

Furnish a type 6 or 12 conflict monitor with respect to the corresponding type 4-A-SS or 8-A-SS controller. It must monitor the Green, Yellow, Red and Walk of each phase.

The front of the monitor unit must contain the MS connector, AC+ power fuse, power indicator, reset switch, signal conflict and Red failure indicators, +24 Volts DC #1 and #2 indicators, controller voltage failure indicator, signal status indicators for each channel, universal removable programming card, initial flash time adjustment control, a RS232 serial communications port, and an LCD display indicating which input on each channel is the conflicting display. All indicators must be LED type.

If a conflict monitor channel is used, bring out all unused inputs to a terminal for future use.

**703.08.4 Flasher.**

Furnish a solid state electronic flasher producing between 50 and 60 flashes per minute with equal on-and-off time intervals meeting all NEMA Type 3 requirements and conforming to part 4B-18 of the MUTCD.

**703.08.5 Solid-State Load Switches.** Accomplish switching of signal lights (external to the controller mechanism) by using solid state switching assemblies. Furnish a load switch meeting all NEMA requirements as to the type. Supply 8 load switches with each type 4-A-SS controller. Supply 12 load switches with each 8-A-SS controller.

**703.08.6 Loop Detectors.** Furnish two channel loop detectors of the rack mount type.

The loop detectors must be solid state digital using external power. The front panel must contain sensitivity controls, mode selector switch, and an actuation indicator LED.

The loop detectors cannot not use more than 150 MA of current at 24 volts DC. The output must be by relay and plug mounted. The relay must be normally energized providing fail-safe functioning should the power fail. Furnish loop detectors meeting all NEMA temperature requirements. Use a 44 pin edge card connector to make all electrical connections.

Supply 4 loop detectors with each type 4-A-SS controller.

Supply 8 loop detectors with each type 8-A-SS controller.

**703.08.7 Railroad Interconnect.** Where railroad interconnects to railroad circuits are specified, the railroad company will furnish a set of normally closed contacts in the railroad cabinet. Perform the traffic signal cabinet to railroad signal cabinet interconnect. Run the circuit conductors in underground, rigid electrical conduit as specified in the Contract. Terminate the conduit in the railroad cabinet as directed by the railroad company engineer. Leave the wire ends projecting at least 3 feet (0.9 m) beyond the end fitting inside the railroad cabinet. The railroad will perform all work inside the railroad cabinet. Do not begin work within the railroad right of way without the Engineer's approval. The Engineer will obtain the railroad's approval and notify the Contractor. The railroad may provide any inspection necessary to oversee

the Contractor's work on railroad right of way. Railroad inspection costs are at Contractor expense.

Observe the railroad special clearances found elsewhere in the contract.

Furnish solid state railroad preemption devices meeting the following requirements:

- A. Signal Operation Preempted by Train.** Any vehicle signal displaying a green shall immediately receive a yellow clearance. The yellow clearance time may be controller-timed or by other timing device with a range of between 0 to 60 seconds.

Any vehicle signal displaying a yellow shall continue to time out the controller-set time or switch to an adjustable timer separate from the controller.

All pedestrian signals shall immediately receive a "DON'T WALK" call.

If vehicle signals are in emergency flashing, they shall remain flashing with the preemptor disconnected from the circuit.

Upon train pre-emption, a red signal shall always be presented to approaching traffic in advance of the tracks.

The signal phasing during railroad preemption is specified in the contract.

- B. Signal Operation After Train Passage.** A signal call for "Green" and/or "Walk" shall be placed on each phase for normal operation once the train has passed.

Any signal having the "Green" indication shall receive a yellow clearance indication. The indication shall be timed on the controller phase or other adjustable timer with limits of 0 to 30 seconds.

Once the yellow clearance interval is timed out the controller shall revert to normal operation unless a special sequence is specified.

**703.09 TYPE "D" CABINET PEDESTAL.** Locate the pedestal as specified or directed. Construct the pedestal, including the concrete work, as specified.

#### **703.10 TRAFFIC AND PEDESTRIAN SIGNALS.**

**703.10.1 Traffic Signal Heads.** Furnish traffic signals meeting or exceeding the Traffic Engineers Technical Report No. 1, USAS D010.1-1966, UDC 656.057, or latest revision thereof. Use AWG No. 14 conductor between the signals and terminal block meeting Subsection 703.06.1. Supply the conductor as a part of this work.

- A. Optical Units.** Furnish the optical unit consisting of a lens, reflector, lamp holder, and 120 volt, clear, 6,000-hour-life, traffic signal lamp. Furnish 116 watt lamps for 8-inch (205 mm) lenses and 150 watt for 12-inch lenses (305 mm).

Furnish the lens color and size specified in the Contract. Use a polycarbonate traffic signal lens true to color.

Furnish an "Alzak" Type reflector.

- B. Signal Housing.** Assemble the signal head housing sections together in a watertight assembly. Each section must house an individual optical unit complete with a one-piece hinged door, a mounting for the lens and other optical system parts, watertight gaskets, and a non-corrodible door-lock.

Mount the optical system so the individual components swing open for access or removal. Assure sections are interchangeable and constructed so sections can be added or removed. Each section must have a round opening in the bottom and top to receive a 1½-inch (38 mm) supporting pipe frame. The housing, including the doors and end plates must be die-cast aluminum, clean and smooth, free from flaws, cracks, blow holes, or other imperfections. Hinges, pins, lens clips, and locking devices shall be non-corroding metal.

Mount a terminal block inside at the back of the housing. Wire all sockets with a white wire connected to the socket shell and a black wire to the bottom or end terminal of the socket. Connect these wires to the terminal block mounted in the housing.

The terminal block must have studs to terminate all field wires and lamp wires independently. Permanently identify the terminals.

Where terminal compartments are used, terminal blocks in the heads may be omitted.

Supply with each lens a removable tunnel visor (open bottom) of the appropriate size made from at least 0.050-inch (1.3 mm) thick aluminum.

The inside surface of all visors shall be flat black.

- C. **Back Plates.** Furnish and install back plates on all traffic signal heads to form a 5-inch (130 mm) border around the signals. Make backplates from at least 0.058-inch (1.5 mm) sheet aluminum. Paint back plates under Subsection 617.03.12.
- D. **Mounting Brackets.** Mount signal heads using brackets made from 1½-inch (38 mm) standard steel pipe and malleable iron or brass pipe fittings. Plumb or level all elements, symmetrically arrange, and securely assemble. Conceal all conductors in the poles and assembly. At each signal location, construct a terminal compartment in the bracket system as shown on the plans. Bracket mounted signals that are post top mounted must have a terminal compartment cast with an integral slip-fitter. For post-top mounted one-way signal head, a slip-fitter without a terminal compartment may be used. Fit the slip fitter over a 4-inch (105 mm) standard pipe. Provide each slip-fitter with 2 rows of 3 set screws in each row to plumb the assembly. Use cadmium plated set screws. Signal heads mounted on luminaire standards or other tall poles must have a terminal compartment to bolt or clamp securely to the pole.

Provide each compartment with a terminal block with twelve terminals, each with two pressure type connectors. Size each connector to accommodate at least five No. 14 conductors.

Provide the terminal compartment with an access opening to the terminal block with a rain-tight cover. All slip-fitters and terminal compartments must be made of non-frangible metal.
- E. **Signal Head Mounting.** Mount signal heads as shown on the plans. Use the standard mounting for all three-section mast arm mounted signals, unless 17.5 feet (5.3 m) of roadway clearance cannot be obtained. Use an elevator plumbizer, when necessary, to obtain the 17.5 foot (5.3 m) clearance.



Elevator plumbizer mount all four and five section signals.

Use internally wired plumbing devices for mounting signal heads to mast arms.

Provide positive lock rings and fittings for all signal heads. Use rings and fittings with serrated contacts.

**F. Installing Signal Heads.** Install signal heads after all other signal equipment is placed and ready for operation, or cover the signal faces with an opaque covering.

**G. Directional Traffic Signals.** The traffic signals must be optically-programmed and visible only to a specific area of the intersection.

Use 150-watt PAR lamps for optically-programmed signal lamps.

Furnish back plates, mounting brackets, installation, and mounting meeting Subsections 703.10 (C),(D),(E),(F) and (G).

**703.10.2 Pedestrian Signals.** Furnish pedestrian signals rectangular in shape containing the letter messages "WALK" and "DON'T WALK" or the international symbols as specified. Letters must be at least 4½-inches (115 mm) high. Furnish international symbols a minimum of 9" (230 mm) high. If, due to electrical or mechanical failure, the word "DON'T fails to illuminate in the "DON'T WALK" lens the signal must not illuminate the word "WALK".

Furnish one piece, watertight, cast aluminum housings with a polycarbonate lenses.

Furnish mounting hardware for pedestrian signals and mount as shown in the Contract and meeting Subsection 703.10.1(D) requirements.

Furnish a terminal compartment with the frame-work for each signal mounting.

Provide AWG No.14 conductors meeting Subsection 703.06.1 from the signals to the terminal compartment as a part of this work.

Use pedestrian signals of the same type within each intersection.

Furnish lunar white "WALK" lens. Furnish portland orange "DON'T WALK" lens with both colors meeting the current requirements of the Institute for Traffic Engineers standards.

Furnish lamps of at least 116 watt, clear traffic signal type rated for 6000 hours of life at 120 volts.

### **703.11 LOOPS, LOOP DETECTORS, AND CABLE.**

**703.11.1 Loops.** Size and install loops as specified in the Contract and to meet the following.

Use one continuous length of No. 12 XHHW wire from the pull box, through the loops and returning back to the pull box. The number of loops is shown on the plans. Twist the loop wires together at 3 turns per foot (305 mm) between the loop and pull box.

Place the loop wire in the saw-cut slot, pour sealant into the slot encapsulating the wire, and fill the slot level to the pavement surface. Sealant must not require a primer.

Sealant must have a non-critical mix ratio allowing application and cure at ambient temperatures of 40 °F (4.4 °C) or higher.

Cured sealant must withstand heavy vehicle traffic and freeze-thaw cycles, be unaffected by water, gasoline, oils, roadway salts, and most corrosive chemicals.

Repair saw cuts through existing pavement markings as directed.

Clean the saw cut slot by high pressure air before placing the loop and sealant.

Make loop wire connections in pull boxes or signal standards using soldered, waterproof splices. Excess make-up wire or lead-in or loop wire coils is not permitted.

Tag loop wire in the pull box, or signal standard if spliced there, with a permanent wire marker indicating the approach, loop number, and "input" or "output".

**703.11.2 Loop Detector.** Furnish loop detectors meeting NEMA requirements and Subsection 703.08.6.

**703.11.3 Detector Loop Shielded Cable.** Furnish cable meeting Subsection 703.06.3.

**703.12 PEDESTRIAN PUSH BUTTONS.** Furnish and install tamper-proof pedestrian push buttons having a direct push button with a single momentary contact switch in a cast-metal housing. The push button must be raised or flush with the housing and be at least 2-inches (50 mm) in the smallest dimension. The push button must activate with less than 5 lbs (22 N) of push force. The push button housing must be weatherproof, and electrically insulated to prevent shock under all weather conditions. Furnish a housing back plate to fit the pole curvature and, when required, provide saddles to make a near fit. Furnish and install push button signs shown on the plans. Install the push button and sign on the crosswalk side of the pole with the arrow pointing in the direction of the crosswalk.

Field drill and tap signal standards treating the holes with a rust preventative following the manufacturers directions.

**703.13 LUMINAIRES.** Furnish and install luminaires and lamps meeting these specifications and the contract requirements.

Wire all luminaires for 240-volt operation.

Ballasts and luminaire must be integral, with the ballast providing -20 °F (-29 °C) starting capacity. Multiple ballasts must be 240 volt regulated lag type, .90 power factor, with an operating range of ± 10 percent. Starting and open circuit volt-amperes must not exceed operating values.

Furnish the unit with an independent, replaceable starting board.

The luminaire assemblies must be slip-fitter type, end mounted on a 2-inch (50 mm) pipe tenon.

Check luminaires on the ground to insure they provide the specified ANSI/IES light distribution pattern before mounting. Adjust the luminaires at night, as directed, to provide the best roadway light distribution.

**703.14 PHOTOELECTRIC CONTROLS.** Wire photoelectric controls to meet the contract requirements.

Furnish photoelectric control units of the twist-lock type.

The units shall turn on at  $1.3 \pm 0.5$  foot candles, have a turn-on/off ratio in the range of 1:2 to 1:5 and be rated for a minimum of 1,000 watts at 120 volts.

Incorporate a time delay mechanism into the control preventing operation during brief light condition changes.

Provide a fail safe that leaves the load on or becomes energized if the control fails.

Mount the control at the top of the standard with the photo cell oriented toward the north sky or as directed.

Use AWG No. 14 conductor meeting Subsection 703.06.1 between the photoelectric controller and the electrical service. Supply the conductor as part of this work.

**703.15 EMERGENCY PREEMPTION SYSTEM.** Emergency preemption equipment must be directly interchangeable and compatible with Opticom emergency preemption equipment. Furnish Opticom model 562 discriminators.

Furnish a system using a high-intensity light source to beam a coded message from the emergency vehicles to the detectors at the intersection.

The system will hold the green light in favor of the emergency vehicle or accelerate the normal cycle of the signal change, within NEMA Standards Publication No. TS 1-1976, to provide a standard yellow light clearance, and then a red light stopping traffic across the emergency vehicle path.

When emergency preemption detector cable is included in the system use the cable recommended by the manufacturer or cable meeting Subsection 703.06.4 requirements.

Assure a preemption equipment factory representative provides technical assistance in setting up, checking out, and demonstrating that the system meets functional requirements.

**703.16 CLASS 4 TREATED TIMBER POLES.** Furnish the pole length and place as specified in the Contract.

Furnish class 4, machine peeled poles with 8 feet (2.4 m) of the butt treated with a 5% solution of pentachlorophenol. Seat, backfill, and compact around the poles. Compact backfill in 9-inch (230 mm) lifts. Plumb and rake the pole as directed.

### **703.17 OVERHEAD CONDUCTOR LIGHTING INSTALLATION.**

**703.17.1 Luminaire.** Furnish luminaires meeting Subsection 703.13 requirements.

**703.17.2 Lighting Brackets.** Furnish brackets as shown in the Contract that meet or exceed NEMA and IES standards for vertical and horizontal deflection. Use AWG No. 10 copper wiring insulated for 600 volts between luminaire and ballast secondary.

**703.17.3 Wood Poles For Overhead Conductor Highway Lighting.** Furnish wood poles meeting ANSI specifications. The poles must be straight so that a line drawn from the butt center to the top center will pass through the pole body. The

poles must be machined-peeled and set to the ANSI recommended depth. Set poles plumb and true to line. Compact backfill in 9-inch (230 mm) lifts.

Pressure treat the bottom 8 feet (2.4 m) of the poles with a 5-percent by weight pentachlorophenol solution or Chromated Copper Arsenate (CCA), type B or C, or Ammoniacal Copper Arsenate (ACA) meeting AWWA standards and Section 706 requirements.

Repair pole finish damage as directed.

**703.17.4 Steel Poles for Overhead Conductor Highway Lighting.** Furnish steel poles meeting Subsection 703.04.3 and 703.04.4 requirements.

**703.17.5 Line Material.** Furnish all line material that meets the Contract requirements and the following.

Furnish insulators for brackets, clevises and upset bolts of the wet process type, 3-inch (75 mm) diameter X 3/16-inch (5 mm), 5/8-inch (16 mm) bolt hole having a 7/16 (11 mm) radius wire slot, and vertical mounting. It must be rated for wet flashover of 14KV, horizontal mounting wet flashover 17KV, dry flashover 26KV, and ultimate mechanical strength of 5,000 pounds (2,270 kg ).

Furnish double upset bolts of 9/16-inch (14 mm) steel with 5/8-inch (16 mm) rolled threads, 1½-inch (38 mm) upset to upset, and 4½-inch (115 mm) threaded insulator end with cotter key.

Use insulated brackets that are spool clevises of the cross arm mounting type constructed of 1¼ X ½-inch (45 X 3 mm) steel providing a ¾-inch (19 mm) mounting hole and a 5/8-inch (16 mm) cotter pin for mounting the insulator. The clevis must provide a 5-inch (130 mm) distance from the center of the insulator to the mounting face.

Furnish insulated swinging clevises of 1½ X 3/16-inch steel (38 X 5 mm), 5-inches (130 mm) from 5/8-inch (16 mm) cotter pin to eye attachment for 3-inch (75 mm) insulator and 5/8-inch (16 mm) eye-bolt or eye-nut.

Furnish copper to copper connectors of high strength silicon bronze threaded with spacer and nut. Use aluminum to copper connectors of an aluminum-alloy bolt and nut with a plated copper spacer and plated copper contact. Remove the plating from the contact surfaces to identify the copper conductor location.

Insulated tension splices must have a 4-inch (100 mm) insulated length. Size the tap wire attaching clips for the appropriate wire size being installed. Obtain the Project Manager's approval before installation. Use insulated tension splices where required, in series installations, as follows:

1. Do not locate splices closer than 18-inches (460 mm) from a support point.
2. Do not locate splices in spans crossing a highway, street, or railroad.

Do not use conductor with cuts, kinks, or other injuries.

On angle assemblies, place the conductors on the insulator side away from the strain and tie it in place as shown on the plans. Sag all wire with the Project Manager present who will provide the sag tables. Provide an approved thermometer for the temperature reading. Gradually pull the wire to the required sag, keeping the wire free to move at intermediate support points. Do not pull wire beyond the required sag.

**703.17.6 Guys and Anchors.** Install guys and anchors as specified. Use two strain insulators in all guy spans. Use Eye-bolts, eye-nuts, and anchor rods with thimble eyes when used on guys. Furnish eye-bolts and eye-nuts used on down guys of the 45° angle type.

Use 3/8-inch (9.5 mm) Siemens-Martin seven strand, galvanized guy wire meeting ASTM A 363.

Use three medium duty bolt clamps where necessary. Draw all three bolts up tight. Clamps using a stainless steel bail for straight through dead ending of the guy wire are an acceptable alternate to guy clamps.

Furnish 8 feet (2.4 m) long, full round gauge 14 galvanized steel guy protectors.

Use strain insulators meeting the following:

Rated Voltage, KV .....	4.4
Flashover Voltage: 60 CY, Dry KV .....	30
60 CY, Wet KV .....	15
Mechanical Strength, Pounds .....	12,000 (53.3 kN)
Max. Cable Size, Inches .....	1/2" (13 mm)
Length, Inches .....	4-1/8" (105 mm)
Width, Inches .....	2-7/8" (73 mm)

Provide anchors and rods as specified. Install in line with the strain and installed with approximately 6-inches (155 mm) of the rod projecting out of the ground. Backfill the hole with course crushed rock 2 feet (610 mm) above the anchor, compacting in 6-inch (155 mm) lifts for the full depth.